23. A method as claimed in claim 21, wherein said non-oxidizing gas is selected from a group consisting of Ar, He, Ne, Xe and N_2.

24. A method as claimed in claim 21, wherein said oxidizing gas is selected from a group consisting of O_2, N_2O, NO and NO_2.

25. A method as claimed in claim 21, wherein said step of crystallizing said ferroelectric film is conducted by a rapid thermal annealing process.

26. A method as claimed in claim 21, wherein said step of forming said ferroelectric film comprises the step of forming said ferroelectric film by a sputtering process.

27. A method as claimed in claim 26, wherein said ferroelectric film has a perovskite structure.

A3 cancel

28. A method as claimed in claim 27, wherein said ferroelectric film is a film of zirconate titanate of Pb.

REMARKS

A. Summary of the Office Action

Formal drawings are requested.

Claim 7 stands rejected under 35 U.S.C. § 112, second paragraph, as being indefinite.

Claims 1-14 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Cuchiaro et al. (U.S. Patent No. 6,165,802) in view of Larson et al. (U.S. Patent No. 5,206,788).

Claims 15-20 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Cuchiaro et al. in view of Larson et al., and further in view of Perino et al. (U.S. Patent No. 5,426,075).

B. Summary of the Response to the Office Action

Claim 3 has been canceled without prejudice and disclaimer. Claims 1 and 7 have been amended. New claims 21-28 have been added. Accordingly, claims 1, 2, and 4-28 are pending.

C. The Rejections Under 35 U.S.C. § 112 are Addressed.

Applicant respectfully submits that claim 7, as amended, fully complies with the requirements of 35 U.S.C. § 112, second paragraph. Accordingly, Applicant respectfully requests that the rejection of claim 7 under 35 U.S.C. § 112, second paragraph, be withdrawn.

D. The Rejections Under 35 U.S.C. § 103(a) are Addressed.

Applicant respectfully traverses the rejections of claims 1-14 under 35 U.S.C. § 103(a) as being unpatentable over Cuchiaro et al. in view of Larson et al., and requests reconsideration.

Independent claim 1, as amended, recites a method of fabricating a semiconductor device **"wherein said step of crystallizing said ferroelectric file is conducted by setting a composition of said atmosphere such that said atmosphere contains said oxidizing gas with a fraction of 1 to 50% in volume."** The references, whether taken individually or in combination, do not teach or suggest at least this limitation of claim 1.

As the Office Action, at page 4, admits, Cuchiaro et al. does not teach or suggest a thermal annealing process in an atmosphere containing a non-oxidizing gas and an oxidizing gas. Accordingly, Cuchiaro et al. does not teach or suggest a composition of the atmosphere containing an oxidizing gas with a fraction of 1 to 50% in volume, in addition to the defect stated above. Further, Larson et al., the reference used by the Office Action in attempt to cure the defect of Cuchiaro et al., does not teach or suggest crystallizing of a ferroelectric file being conducted in an atmosphere containing an oxidizing gas with a fraction of 1 to 50% in volume, as recited in amended claim 1.

MPEP § 2142 instructs that "To establish a prima facie case of obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art." *In re Royka*, 490 F.2d 981, 180 USPQ 580 (CCPA 1974).

Since the applied references fail to meet this requirement for establishing a *prima facie* case, the Office Action fails to establish a *prima facie* case of obviousness as to claim 1. Therefore, Applicant respectfully requests that the rejection of claim 1 under 35 U.S.C. § 103(a) be withdrawn.

With regard to dependent claims 2, 4-11 and 13, Applicant submits that the claims are allowable at least because they depend from and incorporate all the features of allowable claim 1, and for the same reasons that claim 1 is allowable. Accordingly, Applicant respectfully requests that the rejections of claims 2, 4-11 and 13 under 35 U.S.C. § 103(a) be withdrawn.

With regard to independent claim 12, the claim recites a method of fabricating a semiconductor device including the step of "crystallizing said ferroelectric film by applying a thermal annealing process in an atmosphere of an oxidizing gas under a reduced total pressure smaller than an atmospheric pressure." The references, whether taken individually or in combination, do not teach or suggest at least this limitation of claim 12.

The Office Action asserts that "Cuchiaro et al. teach the claimed method of fabricating a semiconductor device, . . . comprising the steps of: . . . crystallizing said ferroelectric film 122 by applying a rapid thermal annealing process in an atmosphere containing an oxidizing gas, such as oxygen, under a reduced total pressure smaller than an atmospheric pressure (col. 8, lines 20-30)." However, column 8, lines 20-30 in Cuchiaro et al. states:

> The application step 222 is preferably followed by a treatment step 224 which preferably includes a drying step, a crystallization substep at elevated temperatures such as a rapid thermal process, and may include treatment with ultraviolet radiation during or after the application step 222. For example, in a typical spin-on procedure, a coat of the precursor might be applied and dried. Then another precursor coat might be applied and dried. The application and treatment steps 222 and 224 can be repeated several times. The treated film is then annealed in oxygen to form the resulting ferroelectric thin film in step 226. Following steps 222-226, the top electrode is formed in step 228.

Cuchiaro et al. does not teach or suggest anything about a pressure. Accordingly, Cuchiaro et al. does not teach or suggest applying a thermal annealing process under a reduced total pressure smaller than an atmospheric pressure, as recited in claim 12.

Accordingly, the Office Action fails to establish a *prima facie* case of obviousness as to claim 12 for the reasons set forth above. Therefore,

Applicant respectfully requests that the rejection of claim 12 under 35 U.S.C. § 103(a) be withdrawn.

With regard to independent claim 14, the claim recites a method of fabricating a semiconductor device "wherein said step of crystallizing said ferroelectric film is conducted by supplying O_2 controlled to cause an oxidation in said Ti atoms reached a surface of said lower electrode from said layer part containing Ti atoms." The references, whether taken individually or in combination, do not teach or suggest at least this limitation of claim 14, and further, the Office Action fails to indicate otherwise.

Accordingly, the Office Action fails to establish a *prima facie* case of obviousness as to claim 14 for the reasons set forth above. Therefore, Applicant respectfully requests that the rejection of claim 14 under 35 U.S.C. § 103(a) be withdrawn.

Applicant respectfully traverses the rejections of claims 15-20 under 35 U.S.C. § 103(a) as being unpatentable over Cuchiaro et al. in view of Larson et al., and further in view of Perino et al., and requests reconsideration.

Independent claim 15 recites a semiconductor device including

> a ferroelectric film provided on said lower electrode, said ferroelectric film having a columnar microstructure extending from an interface between said lower electrode and said ferroelectric film in a direction substantially perpendicular to a principal surface of said lower electrode, said ferroelectric film essentially consisting of crystal grains having a generally uniform grain diameter of less than about 200 nm.

The references, whether taken individually or in combination, do not teach or suggest at least this limitation of claim 15.

The Office Action, at page 4, states that

> The combination of Cuchiaro et la. ('802) and Larson et al. ('788) substantially teaches the claimed semiconductor device except that ferroelectric film having a columnar microstructure substantially perpendicular to a principal surface of said lower electrode, and said ferroelectric film essentially consisting of crystal grains having a generally uniform grain diameter of less than about 200 nm.

Then, in attempt to cure the defects of Cuchiaro et al. in view of Larson et al., the Office Action asserts that

> Perino et al. ('075) teach that as a ferroelectric film was subjected to crystallization annealing, the microstructure of ferroelectric film has a columnar microstructure oriented perpendicular to a surface of a substrate, and said ferroelectric film has crystal grains having a grain diameter of less than one micron (col. 11, lines 31-50). Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to appreciate that the microstructure of ferroelectric film after crystallization annealing is a columnar microstructure oriented perpendicular to the surface of said lower electrode with a known-range diameter as taught by Perino et al., since such microstructure would be able to react to switching as external field is applied.

However, column 11, lines 31-50 in Perino et al. discloses "a ferroelectric film 60' that is comprised of a plurality of crystal grains, the majority of which are believed to be desirably oriented perpendicular to the surface of the substrate 50. . . . Preferred grain size is less than one micron in diameter." Perino et al. merely discloses that a ferroelectric film includes a plurality of crystal grains and that the majority of the crystal grains are oriented perpendicular to the surface of the substrate. Perino et al. does not teach or suggest that the crystal grains form a columnar microstructure or that the ferroelectric film has a columnar microstructure extending from an interface between a lower electrode and the ferroelectric film in a direction substantially perpendicular to a surface of the lower electrode, as recited in claim 15. Accordingly, it would not have been obvious to one of ordinary skill in the art at the time of the invention that the microstructure of ferroelectric film after crystallization annealing is a columnar microstructure oriented perpendicular to the surface of the lower electrode.

Since, the Office Action fails to establish a *prima facie* case of obviousness as to claim 15 for the reasons set forth above, Applicant respectfully requests that the rejection of claim 15 under 35 U.S.C. § 103(a) be withdrawn.

With regard to dependent claims 16-20, Applicant submits that the claims are allowable at least because they depend from and incorporate all the features of allowable claim 15, and for the same reasons that claim 15 is allowable. Accordingly, Applicant respectfully requests that the rejections of claims 16-20 under 35 U.S.C. § 103(a) be withdrawn.

E. Newly Added Claims 21-28.

Claims 21-28 have been added. No new matter has been added.

F. Conclusion.

In view of the foregoing, Applicant respectfully requests the reconsideration and the timely allowance of the pending claims. Should the Examiner feel that there are any issues outstanding after consideration of this response, the Examiner is invited to contact Applicant's undersigned representative to expedite prosecution.

If there are any other fees due in connection with the filing of this response, please charge the fees to our Deposit Account No. 50-1123. If a fee is required for an extension of time under 37 C.F. § 1.136 not accounted for above, such an extension is requested and the fee should also be charged to our Deposit Account.

Respectfully submitted,

Date: May 17, 2001

Carol W. Burton, Reg. No. 35,465
Hogan & Harrison L.L.P.
1200 Seventeenth Street, Suite 1500
Denver, CO 80202
Telephone: (303) 454-2454
Facsimile: (303) 899-7333

VERSION WITH MARKINGS SHOWING CHANGES TO THE CLAIMS

1. (Amended) A method of fabricating a semiconductor device having a ferroelectric capacitor, comprising the steps of:

forming an active device element on a substrate;

forming an insulation film over said substrate to cover said active device element;

forming a lower electrode layer of said ferroelectric capacitor over said insulation film;

forming a ferroelectric film on said lower electrode layer as a capacitor insulation film of said ferroelectric capacitor;

crystallizing said ferroelectric film by applying a thermal annealing process in an atmosphere containing a non-oxidizing gas and an oxidizing gas; and

forming an upper electrode layer on said ferroelectric film,

wherein said step of crystallizing said ferroelectric film is conducted by setting a composition of said atmosphere such that said atmosphere contains said oxidizing gas with a fraction of 1 to 50% in volume.

7. (Amended) A method as claimed in claim 1, wherein [said step of forming] said ferroelectric film comprises the step of forming said ferroelectric film by a sputtering process.